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ABSTRACT

It is argued that the analysis of stress placement in Piraha offers important new evidence on the proper characterization of prosodic organization and the notational devices necessary to express this organization. It is shown that Piraha stress placement is intractable to either a grid account or a binary branching analysis, but that an insightful perspective on a variety of stress-related phenomena is available if it is assumed that the language has ternary, obligatory branching feet. Evidence is presented from the assignment of stress in morphologically simple words, lexical compounds, words with extrametrical suffixes, and transmorphemic stress shifts and clash resolutions. (Author/MSE)

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TERNARITY AND OBLIGATORY BRANCHING IN PIRAHÃ*

Daniel Everett

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1 Introduction

A central concern of multilinear phonology, as developed by Liberman and Prince (1977); Hayes (1981); Prince (1983); Hammond (1984); Halle and Vergnaud (forthcoming); and others, has been the characterization of the major components of prosodic structure: **hierarchy, directionality**, and **quantity**. Hierarchy is the organization of prosodic units into phonological constituents, e.g. syllables and feet. Directionality refers to the general orientation, left-to-right, of phonological process at a given structural level. Quantity may be understood as relative structural complexity, expressed in terms of particular notational devices (such as branching or grid complexity) or by less theoretical vocabulary, such as syllable weight.

In this paper it is argued that the analysis of stress placement in Pirahã offers important new evidence on the proper characterization of prosodic organization as well as the notational devices necessary to express this organization[1]. Specifically, I will show that Pirahã stress placement is intractable to either a **grid** account (Prince 1983) or a binary branching analysis but that an insightful perspective on a variety of stress related phenomena is available if we assume that Pirahã has ternary, **obligatory branching** feet. Evidence is presented from the assignment of stress in morphologically simple words, lexical

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compounds, words with **extrametrical** suffixes, and transmorphemic stress shifts and clash resolution.

2 The basic facts

The rule of stress placement in Pirahã may be stated as in (1) (see also Everett and Everett (1984) and Everett (1985; 1986, Sect. 22)):

(1) Pirahã stress placement (initial statement):
Stress the rightmost token of the heaviest syllable type in the word.

Syllable weight relations are expressed (2): (where **C** = voiceless consonant; **G** = voiced consonant; . = 'is heavier than')

(2) CVV>GVV>VV>CV>GV

Rule (1) correctly predicts stress placement in the following examples (bold = stress; . = syllable boundary).

(3) Rightmost Token

a.	paó. hoa. **hai**	'anaconda'
b.	ba. hói. ga. **toi**	'domesticated pig'
c.	bai. tói. **sái**	'wildcat'

(4) CVV vs GVV

a.	bii. **sai**	'red'
b.	**kai**. bai	'species of monkey'

(5) CVV vs VV

a.	xi. **sii**. ho. ái	'liquid fuel'
b.	ko. so. ii. gai. **tái**	'eyebrow'

(6) CVV vs CV

a.	**xoo**. gi. ái.	'proper namé
	xo. gi. **ái**	'big'
b.	**tai**. si	'axe'
c.	si. **tai**	'feather'

(7) CVV vs GV

a.	**xaa**. gí	'coati mundi'
b.	ga. **hió**	'airplane'

(8) GVV vs VV

a.	**gao**. ii	'proper name'
b.	ho. aa. **gai**	'species of fruit'

(9) GVV vs CV

a.	xi. **gaó**	'back (body part and locational)'
b.	**gái**. hí	'that'

(10) GVV vs GV

a.	bó. **gai**	'breast'
b.	**gaa**. ba	'next'

(11) VV vs CV

a.	pí. **ai**	'also'
b.	ho. **ai**. pi	'proper name'

(12) VV vs GV

a.	xa. **ai**. bi	'thin'
b.	**si**. ga. **ii**	'fins'

(13) CV vs GV

a.	**xa**. ba gi	'toucan'
b.	xa. ba **pa**	'proper name'

An important theoretical implication of Pirahã stress has already been pointed out in Everett and Everett (1984) and Davis (1985), namely, that the stress placement rule crucially refers to the syllable onset. Consequently, contrary to many current works (see especially Hyman 1985), stress placement may be based on the **syllable projections** rather than merely **rime** or **nucleus projections**.

I want to focus here, however, on a different but equally important facet of Pirahã stress - the restriction of stress to the final three syllables, as illustrated in (14)-(18):

(14)	pia. hao. gi. so. **ai**. pi	'cooking banana'
(15)	poo. **gái**. hi. aí	'banana'
(16)	kao. **ái**. bo. gi	'jungle spirit'
(17)	ka. pii. ga. ií. to. **ii**	'pencil'

(18) poo. so. gi. **ái** 'species of fish'

In each of the examples in (14)-(18), stress can only be placed on one of the final three syllables, in spite of the fact that a heavier syllable type (CVV) occurs to the left of the antepenult.

Superficially, this restriction does not look too unusual. It is certainly easy to state in prose. Also, it is not perhaps immediately apparent that Pirahã differs radically from better known languages, such as Spanish. As Harris (1983) shows, Spanish stress is limited to the final three syllables, interacts with syllable weight, and may appear on either the antepenult, the penult, or the ultima. On closer examination, however, the way in which the domain of stress placement is determined in Spanish (and other similar cases I am aware of) is drastically different than in Pirahã. According to Harris' (1983) analysis, noun stress in Spanish is penultimate, except in words like **papá** 'dad' which have no gender suffix (what Harris (1983, 91ff) calls the **Terminal Element**). Apparent counterexamples, such as **nómada** 'nomad' (cf. **pomáda** 'cream') may be characterized by making the preTerminal Element **extrametrical** (i.e. not counting for stress placement).

Thus, at least by this analysis, the fact that Spanish stress is limited to the final three syllables is an epiphenomenon of no particular theoretical or language particular significance.

In Pirahã, however, there are no lexically assigned stresses. Further, although, as we see directly, Pirahã does have extrametrical syllables these are a very restricted class and can not be appealed to account for any but an infinitesimal portion of proparoxytones. Thus, a theory of Pirahã stress must be able to drive a three syllable domain as the unmarked case.

The immediately following sections attempt to show that neither a grid only account nor a binary branching analysis is able to meet this condition. Following this discussion I argue that a ternary branching analysis can handle the Pirahã facts easily with only minimal modifications of descriptive devices and principles already available in metrical theory.

3 Two failed analyses

3.1 The grid

The grid is unable to recognize the final three syllables as a single constituent, except by stipulation. To see why, consider Prince's (1983, 87) comments on feet:

> "It is a simple matter to divide the grid into feet. A falling or leftheaded foot starts with a $\langle$-level grid entry and runs rightward until another such entry is encountered or the end of a domain. A rising or rightheaded foot is the mirror image opposite."

Since Pirahã stress falls on the last three syllables, foot delimitation must operate from right to left. Now consider the following hypothetical cases. Heavier syllables will register higher on the grid since Pirahã stress is quantity sensitive.[2]

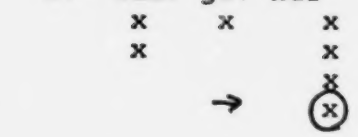
(19) a. CVV. CV. CV [CVV] [CV.CV]
b. VV. GV. CV [VV] [GV.CV]
C. CVV. CV. CV. GV [CVV] [CV.CV.] [GV]

Each of the parsings in (19) fails to recognize that the crucial prosodic domain for Pirahã stress placement is the final three syllables. The grid can only express this as a stipulation, if the statement in (1) is correct. But perhaps the grid can be saved by an alternative conception of Pirahã stress. Let us assume that Pirahã stress is in fact penultimate but that it is subject to the restriction that the penult can only bear the highest level grid mark if neither the ultima nor the antepenult is heavier. If either of these is heavier (thus registering higher on the grid than the penult) the heaviest will be stressed. If both are equal (and heavier than or equal to the penult) the ultima will be stressed. This would be formalizable as in (20)-(22):

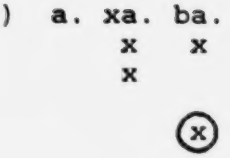
(20) a. baá. ga. hái 'potato' (underlying form)

```
x     x     x
x           x
            x
      (x)
```

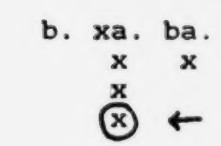
b. baá. ga. hái — Move (x) to ultima



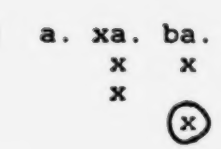
(21) a. xa. ba. gi — 'toucan' (underlying form)



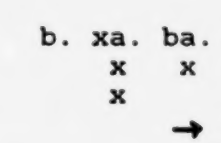
b. xa. ba. gi — Move (x) to antepenult



(22) a. xa. ba. pa — 'proper name' (underlying form)



b. xa. ba. pa — Move (x) to ultima



By conceiving of Pirahã stress as primarily penultimate but subject to quantity sensitivity we are indeed able to come up with a description in a grid-like notation. However, such an approach in effect renders the grid meaningless. The layer at which (x) is represented in (20)-(22) bears no principled relation to lower levels of the grid. And yet, at the point where (x) is moved, these lower levels **do** become important, determing the applicability and directionality of the rule (in grid theory, **Move-x**). This global character violates the basic thesis of Prince (1983) that the grid provides a constrained theory of metrical structure by relating each level to immediately preceding levels in a principled manner. Since there is no such relation between levels in (20)-(22), this analysis reduces the grid to the role of a mere descriptive artifice, offering no insights based on independently needed principles and thus explaining nothing. Therefore, it seems that a grid only treatment of Pirahã stress is unavailable.

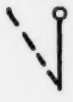
3.2 Binary trees

Hammond (1984; 1985; 1986) has developed an interesting version of tree theory based on earlier work by, interalia, Halle and Vergnaud (1978; forthcoming) and Hayes (1981). He argues (Hammond 1984, 22ff) that grids alone are inadequate to explain phonological constituent structure (a conclusion forced independently by Pirahã data, as seen above). As already noted, phonological feet are of little theoretical significance in grid theory. But Hammond argues that there are a number of phonological processes which crucially refer to phonological feet. Thus, a theory of prosody must include metrical trees which explicitly recognize the importance of feet. Moreover, in Hammonds tree theory, both rhythmic beat placement (the primary contribution of the grid in earlier metrical analyses, e.g. Liberman and Prince 1977) and phrasing (foot structure) are expressable in a single notation, obviating the need for grids. Hammond's work thus represents an important development and restriction of the formal representations of metrical theory. Finally, Hammond argues that tree structure itself be severely constrained by (i) allowing only binary or unbounded trees and (ii) eliminating all tree structure changing rules except **pruning**.[3]

I argue below that the restriction of trees to binary branching is empirically unjustifiable. Before attempting a tree analysis of Pirahã stress, however, the concept of **obligatory branching** must be introduced. This idea, due originally to Hayes (1981), is interpreted by Hammond (1986) to require, for certain cases in languages in which syllable weight is phonologically relevant, that the terminal, **strong (s)**, nodes may only dominate heavy syllables, whereas nonhead, **weak (w)**, nodes may dominate either heavy or light syllables. In Hammond's model, the **strong** terminals are called **Designated Terminal Elements (DTE)**. To see how obligatory branching works, consider the following Turkish examples (Hammond 1981, 11).

(23) a. Antálya 'city in Turkey'

b. lokánta 'restaurant'



c. Ankara 'city in Turkey'

d. Kenedi 'Kennedy'

In (23a-c), right dominant feet are built from the first heavy (i.e. closed) syllable, in conformity with the obligatory branching parameter. Since (23d) has no heavy syllables, obligatory branching is inapplicable. In these cases, stress defaults to the penult.

(24) Kenedi

Remaining syllables will be attached by the principle of **stray syllable adjunction**:

(25) a. Antálya

b. Iokánta

c. Ankara

d. Kenedi

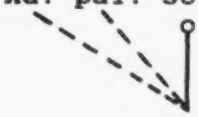
Given these basic notions, let us see how the binary model plus obligatory branching fares in Pirahã. First, as in a grid only account, we must stipulate that the primary focus of stress placement is the penult. To see why, consider how a nonrestrictive algorithm such as (26) would stress the examples in (27) and (28)[4]:

(26) Pirahã stress placement (first restatement):
a. Construct a single obligatory branching, right dominant foot from the right.
b. Join all unattached syllables in a single (unbounded) foot via stray syllable adjunction.

(27) a. paó. hoa. hai 'anaconda/rainbow'

b. xa. ba. gi 'toucan'

c. xa. paí. soí 'shoe'



Once again, though, heavy syllables left of the antepenult cause problems.

(28) a.* poo. gái. hi. aí 'banana'

b.* kao. ai. bo. gi 'jungle spirit'

c.* pia. hao. gi. so. ai. pi 'cooking banana'

To prevent the tree based analysis from stressing the examples in (28) incorrectly, we must stipulate that the penult is the "pivot" for the stress rule.

(29) Pirahã stress placement (second attempt):
- a. Mark the penult as a Designated Terminal Element (DTE)
- b. Shift the DTE to the ultima if it is as heavy or heavier than penult or antepenult.
- c. Shift the DTE to the antepenult if it is heavier than the penult or ultima.
- d. Build a binary tree whose head is the DTE.
- e. Stray syllable adjunction.

In effect, (29) allows the stress rule to look only to the immediate left or right of the penult, thus limiting stress to the final three syllables. The problem with (29) is that it shifts the DTE without regard to tree structure. This makes it little more than a restatement of the grid treatment in (20)-(22). Consequently, it will face the same problems as the grid. So, let us try again with (30):

(30) Pirahã stress statement (third attempt):
- a. Label the penult as the DTE.
- b. Build a left dominant (binary) tree if the ultima is as heavy or heavier than the penult and antepenult. Otherwise, build a right dominant tree.
- c. Shift the DTE of the resultant tree in accordance with obligatory branching.
- d. Stray syllable adjunction.

As seen in (30c), I am assuming that obligatory branching can be interpreted as a condition on tree representations rather than tree construction. This interpretation enables us to account for the DTE shift by genuine tree geometry principles rather than as a disguised version of Move-x, as in (29). As (31)-(33) illustrate, (30) can indeed describe the facts:

(31) a. paó. hoa. hai (30a) and (30b)

b. paó. hoa. hai (30c)

c. paó. hoa. hai (30d)

(32) a. poo. gáî. hi. aí (30a) and (30b)

b. poo. gái. hi. aí (30c)

c. poo. gái. hi. aí (30d)

(33) a. pia. hao. gi. so. ai. pi (30a) and (30b)

b. pia. hao. gi. so. ai. pi (30c) N/A

c. pia. hoa. gi. so. ai. pi (30d)

Unfortunately, (30) has two serious problems. First, it allows trees in the same domain to branch in either direction. Of course, it is not uncommon to find languages in which foot construction and higher level constituents, such as word trees, are oriented in opposite directions. But to allow trees to branch in either direction at the same level, determined by global properties (e.g. (30d)), would seriously weaken tree theory.[5] Second, this analysis clouds the issue by attempting to relate Pirahã's stress to

apparently similar cases, e.g. Spanish, with penultimate stress. Whereas in these other cases penultimate stress is the most common phenomenon, deviations being explicable via well motivated principles or as lexical exceptions, in Pirahã, penultimate stress is in fact no more common than antepenultimate or ultimate stress. Stipulating the penult as somehow basic thus is an artificial caricature of Pirahã stress. Therefore, it is clear that the restriction of stress placement in Pirahã to the final three sylables, far from being innocuous, presents what appear to be insurmountable theoretical and empirical difficulties for either a grid or a binary tree analysis.

4 Ternarity and obligatory branching

4.1 Amphibrachs

The task of this section is to establish that the problems faced by the grid and binary trees admit of a rather straightforward solution if we assume a particular parametrization of the tree theory conditions outlined by Halle and Vergnaud (forthcoming). The original suggestion for such a parametrization is found in Levin (1985).

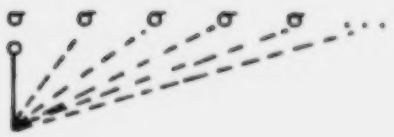
Halle and Vergnaud (forthcoming) propose the following.

(34) Conditions on Metrical Structure
a. Every metrical constituent has a head.
b. The head is peripheral.
c. The domain is immediately adjacent to the head.

To derive **unbounded** tees (i.e. those with an unrestricted number of branches) Halle and Vergnaud suggest that (34c) be parametrized[6]. However, as Levin (1985, 15) points out, if (34b) were also parametrized, (i.e. if the head need not occur on the right or left) trees with an internal head could also be generated. Levin (1985, 15) claims that this will generate ternary feet of a single type. Unfortunately, this will generate a large number of undesirable structures as well;

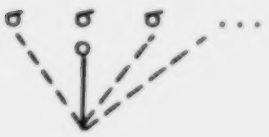
(35) Parametrization of (34c) only:

a.

b. 

(36) Parametrization of (34b) only:

(37) Parametrization of (34b) and (34c)

a. 

b.

c.

If Levin's proposal is to be accepted, we must first address the fact that absolutely no languages with head internal, unbounded feet have been documented (and it seems unlikely that any will be).

The simplest solution to our problem would be to disallow either the parametrization of (34c) or of (34b). As a matter of fact, there is no reason to allow (34c) to be parametrized. That is, we need not accept unbounded feet as a primitive of tree theory. Recall that metrical theory must have a rule of stray syllable adjunction. If we require all feet to be binary, except for these produced by the parametrization of (34b), as in (36) above, then "unbounded feet" can be trivially derived by the subsequent application of stray syllable adjunction. This is in fact

what I will assume here (cf. Prince (1985,472) for a similar conclusion).

The structure in (36), produced by the parametrization of (34b) is a particular type of ternary tree, the amphibrach. If we propose that every Pirahã word builds an amphibrach at the right margin (vacuously for disyllables and monosyllables), the three syllable domain of stress placement is automatically accounted for. However, very few words are stressed on the penult, as we have seen. For antepenult and ultima stress the structure in (36) can not be right. Thus, to adequately describe these words, something else is needed. I submit that this "something else" is the obligatory branching parameter, once again interpreting this as a postlexical condition on representations. When more than one syllable in a tree may satisfy obligatory branching, the default value is rightmost. Pirahã stress placement may be stated as in (38).

(38) Pirahã stress placement (final version):
  a. Build an amphibrach at the right margin of the word.
  b. Obligatory branching (default value = rightmost).
  c. Stray syllable adjunction

4.2 Stress in the lexicon

I want to further argue that (38) applies in the lexicon. The evidence for this claim is the fact that secondary stresses arise only in syntactically formed compounds but not in lexical compounds:

(39) **xabagi +soaipi** 'saw'
toucan - beak

(40) **piahaogi +soaipi** 'cooking banana'
dolphin - beak

(41) **kapiiga +xii +toii** 'pencil'
paper - wood - handle

(42) **sabáasi +sigapai+sai** 'syringe'[8]
spirit - piercer - nominalizer

Lexical compounds are recognizable for the facts that (i) the resultant meaning is often much different from the meaning of the compound morphemes, (ii) compounds have the same distribution as single nouns (they may be heads of NPs), (iii) compounds have a single, primary stress. Now consider the examples in (43)-(44) (___ 'primary stress'; 'secondary stress'):

(43) poogáihiái xogabagai -- poogáihiogabagai
'want a banana'

(44) kahai hoáobá --- kahihoáobá
arrow give 'give an arrow'

More examples of the phenomenon illlustrated in (43) and (44), **morphemic fusion**, are discussed in Sect. 5 below. The important observations here are that, unlike lexical compounds, the examples in (43) and (44) function as complete phrases. Their meaning corresponds one-to-one to the meaning of their component words. Finally, **fused morphemes** allow secondary stresses (which words do and do not allow secondary stresses turn out to be a very strong support for ternarity. See Sect. 5 below.).

The simplest way of accounting for the differences just noted is to claim that stress placement applies in the lexicon compounding (thus accenting the result as a single word) but prior to (syntactic) morphemic fusion, where both components of a phrase are accented. It is argued below that rules of resyllabification may alter tree structure in such a way as to shift stress postlexically. But in the absence of such overriding considrations stress will reflect as closely as possible the presyntactic stress pattern. Before considering a wider range of stress facts, it would be worthwhile wo sum up the discussion to this point.

4.3 Summary

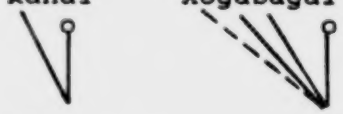
First, it was demonstrated that neither a grid only nor a strictly binary tree analysis is able to express the limitation of Pirahã stress to the final three syllables, without seriously weakening metrical theory. Next, it was shown that by allowing parametrization of the head peripherality condition (but **no** parametrization of the head adjacency condition), amphibrachs may be generated. Finally, I argued that by interpreting obligatory branching as a condition on representations, with a rightmost default value, Pirahã stress placement can be characterized straightforwardly.

In what follows, I will examine a number of the facts which offer independent support for a ternary tree account.

5 Morphemic fusion

In normal speech, in noun + adjective and noun + verb sequences the final vowel of the noun deletes. Also, an initial glottal stop on the following word deletes as well[9]. The entire sequence is then resyllabified from right to left and new tree structure is constructed on the result. The DTE of either word will be shifted after restructuring if needed, via obligatory branching. Whenever two DTEs occur in the same tree following restructuring, the lightest one will be deleted by obligatory branching[10]. A phrase level, right dominant binary tree is constructed over the result.

(45) a. kahaí xogabagaí base forms

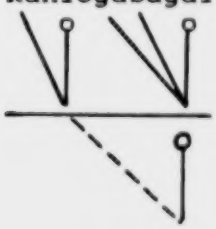


b. kahia metathesis[11]

c. kahi final vowel deletion

d. ogabagaí initial glottal deletion

e. kahiogabagaí restructuring

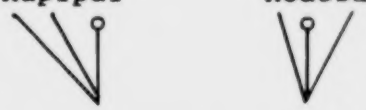


f. phrase tree

'want an arrow'

The derivation in (45) correctly characterizes the fact that in **kahiogabagai** 'want an arrow', the syllable **gai** bears the primary stress and **hio** bears secondary stress. Consider also (46)-(49):

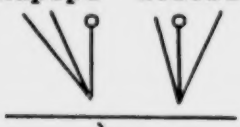
(46) a. xapipái hoáobá base forms



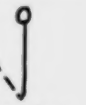
watch give

b. xapipá final vowel deletion

c. xapipá hoáobá restructuring (N/A)



d. phrase tree



'give a watch'

(47) a. xapapaí xiitáha base form

head hurts

b. xapapá final vowel deletion

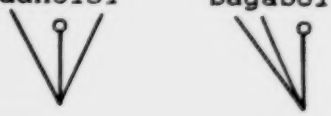
c. iitáhá initial glottal deletion

d. xapapá íítáhá — restructuring (N/A)

e. — phrase tree

'head hurts'

(48) a. baahóísi bagáboí — base forms



pig give

b. baahóís — final vowel deletion

c. baahóí — consonant deletion (see note 9)

d. baahóí bagáboí — restructuring (N/A)

e. — phrase tree

'give a pig'

(49) a. tíihíi xapagí[12] — base forms

Brazil nut many

b. tiihi — final vowel deletion

c. apagi — initial glottal deletion

d. tiihiapagi — restructuring and obligatory branching

e. — phrase tree (vacuous)

'many Brazil nuts'

In (49), the DTE does not shift off of the final syllable in **tiihii** 'Brazil nut' because resyllabification has the effect of replacing the deleted /i/ with the initial /a/ of **xapagi** 'much/many'. Tree construction from right to left will then place 2 DTEs within a single tree, **pa** and **hia**. Obligatory branching will require that only **hia**, the heaviest of these two potential DTEs, be interpreted as the DTE (cf. note 13). Since the **DTE** is transmorphemic, involving also the same morpheme as the first syllable of the phrase, **tii**, this syllable will simply be added to the whole by stray syllable adjunction, rather than bear a secondary stress.

Morphemic fusion of nouns and disyllabic or monosyllabic adjectives and verbs is interesting here since it allows us to test the ternarity hypothesis further. This is so since if ternary trees are rebuilt from right to left, the DTE of an adjective or verb will frequently occur in the same tree as the DTE of the preceding noun. As (50)-(54) show, obligatory branching plus ternary trees makes the correct predictions.

(50) a. sitoi hoi — base forms

egg two

b. sito — final vowel deletion

c. sitohói — restructuring

d. sitohói — oblilgatory branching[13]

e. phrase tree

'two eggs'

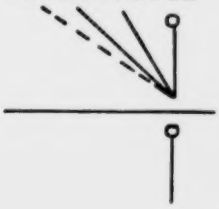
(51) a. kahiai biisai — base forms

basket red

b. kahia — final vowel deletion

c. kahiabiisai — restructuring

d. kahiabiisai — obligatory branching



e. — phrase tree

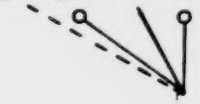
'red basket'

(52) a. poogáihiai hói — base forms

banana one

b. poogáihia — final vowel deletion

c. poogáihiahói — restructuring

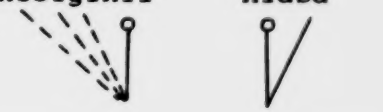


d. poogáihiahói — obligatory branching

e. — phrase tree

'one banana'

(53) a. xisigíhii hiaba — base forms



meat negative

b. xisigíhi — final vowel deletion

c. xísigíhihiaba — restructuring

d. xísigíhihiaba — obligatory branching

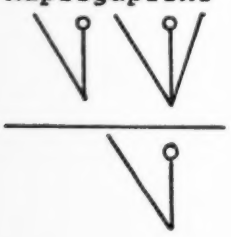
e. — phrase tree

'have no meat'

(54) a. kapiiga piixi — base forms

paper long

b. kapiigapiixi — restructuring/obligatory branching



c. — phrase tree

'long paper'

In (54) two levels of stress are heard even though the following adjective **piixi** 'long' is disyllabic. This is because the DTE of **kapiiga** 'paper' is to the left of the first ternary tree formed from the right following restructuring.

To summarize: in noun + adjective and noun + verb sequences, the DTE of either the noun or following word will delete if it occurs in the same tree as a heavier DTE. Only

a theory allowing ternary trees is able to predict when two DTEs will appear in the same tree. Further, this phenomenon of DTE deletion can not be analyzed as a purely linear restriction against adjacent DTEs since, as examples like (47) show, DTEs may in fact be adjacent if they are in separate trees. This evidence serves to support the proposal in Sect. 4 above that Pirahã stress placement operates within ternary trees.

Now let us conclude this study with a brief look at the interaction of extrametrical syllable and ternary trees.

6 Extrametricality

The following words appear to violate the stress rule given in (38) above.

(55) xoiboi**bii**sai 'species of fish'

(56) ko**hoi**biisai 'proper name'

(57) sigapaisai 'syringe'

(58) kapiigakaga**kai**sai 'calculator'

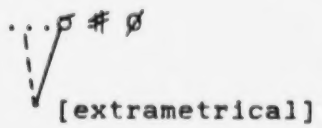
(59) xiixi**boi**tisai 'pencil sharpener'

According to our stress rule, each of these words should be stressed on the final syllable. Interestingly, this is the same in all the examples, the nominalizer, **-sai**. The obvious suggestion is that **-sai** is extrametrical (Hayes 1982). However, **-sai** is still relevant for determining the domain of stress placement, since if it were not, example (55) would be stressed as in (60).

(60) * **xoi**biobiisai

To account for this, we can simply analyse extrametricality as a form of tree pruning (**prior** to obligatory branching).

(61) Extrametricality



By (61), (55) can be derived as in (62):

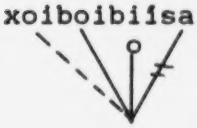
(62) a. xoiboibiisai nominalized form

[extrametrical]

b. xoiboibiisai tree structure

(amphibrach)

c. xoiboibiisai pruning



Extrametricality (-**oai** is the only such syllable I am aware of) thus is consistent with the hypothesis that the domain of Pirahã stress is determined by lexically constructed ternary trees in that extrametrical syllables, although themselves unstressable, still are relevant to determining the final three syllable domain of rule (38).

The extrametrical rule claims that an extrametrical syllable will only be pruned when phrase final. To verify this, consider the interaction of morphemic fusion and extrametricality in (63):

(63) a. xitisai xogabai

bitter medicine wanting

b. xitisa final vowel deletion

c. ogabaí initial glottal deletion

d. xitísaogabaí restructuring

'wanting bitter medicine'

(63) shows that an extrametrical syllable can be stressed in a nonphrase final, restructured environment.

7 Conclusion

In this paper it has been argued that the analysis of Pirahã stress placement makes three important contributions to phonological theory:

(i) Onsets may be relevant for stress placement,
(ii) Ternary trees are a necessary enrichment of metrical theory and are derivable from the parametrization of Halle and Vergnaud's (forthcoming) **head peripherality condition**,
(iii) Obligatory branching (as revised by Hammond (1986)) may be interpreted as a condition on representations rather than tree construction per se.

Notes

* I want to thank the Pirahã, especially **Kohoibiihai** and **Xaópisi**, for putting up with me for these past eight years. My wife Keren has been of inestimable help in discussing, criticizing, and correcting. Juliette Levin, Michael Hammond, Morris Halle, Jay Keyser, Alan Prince, and Moira Yip have all encouraged me to think through the issues here more carefully. High tone is represented as /'/, low tone as /O/. Glottal, /?/, is written as **x**.

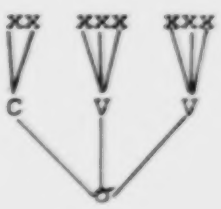
1. This of course implies that notation is significant as a characterization of the properties of **Universal Grammar**, a traditional assumption of generative linguists.

2. In (19) I am assuming that each syllable weight will be considered for foot demarcation, since **heaviest** in (19) is determined relative to neighboring syllables in a given word. Alternatively, we could attempt to scan the word from the right, adding a -level grid mark (**x**), to the first

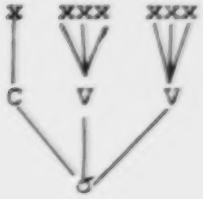
occurence of the heaviest syllable type in the word. This would correctly parse (19a) and (19b) but in examples of the (19c) type (cf. (15)-(18) above) the result would be incorrectly given as [CVV.CV.CV.GV].

3. That is, all trees must be restricted to just two branches or unrestricted.

4. For obligatory branching to work in Pirahã, it must be revised so as to pick out the heaviest syllable type from the five valued scale in (2) above. This could be done in a variety of ways but the most likely seems to be to determine syllable weight via internal branching complexity as in (i) (where long consonants are mapped to two positions on the timing tier - cf. Levin (1985) and Clements and Keyser (1983)). Here I use Levin's (1985) **X** notation:

(i) a. CVV = 

(11 branches)

b. GVV = 

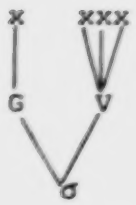
(10 branches)

c. VV =

(8 branches)

d. CV =

(7 branches)

e. GV = 

(6 branches)

5. Hammond (1985, 422ff) discusses a case of bidirectional foot construction in Lenakel verbs:

(i) a. Make the final syllable extrametrical.
b. Build one right-dominant binary foot on the right margin.
c. Build left-dominant binary feet left to right.

Notice though, that this bidirectionality is restricted to opposite margins of the word and is constant for all Lenakel verbs. This is much different than (30). In (30) it is necessary to look at the final three syllables **before** tree construction and determine tree directionality according to surface level accent, a **global constraint**, depriving directionality of any explanatory force.

6. This part of my discussion is essentially a paraphrase of Levin (1985, 14).

7. Note that a word tree will not be necessary.

8. The final syllable in (42), **-sai** is extrametrical and thus not stressable. See Sect. 4.7.

9. When final vowel deletion results in an unsyllabifiable CC sequence, the leftmost C is deleted as in:

(i) xagi báaxi ⟶ xagobáaxái ⟶ xabáaxái
path good 'good path'

the rules are ordered as in (ii)

(ii) a. /V/ ⟶ 0 /___ ≠C
b. C ⟶ 0 /___C

10. We cannot simply derive **new** DTEs in conjunction with resyllabification or restructuring since this would fail to capture the fact that only postlexically fused morphemes but **not** lexical compounds bear secondary stresses. In other words, DTEs are assigned lexically but are subject to the **postlexical** obligatory branching condition. This is one

more support for the conception of obligatory branching as a condition on representations.

11. All **sai** and **hai** syllables undergo metathesis before final vowel deflection. See Sheldon (1974) for discussion.

12. The DTE of **xapagi** will be deleted presumably because of resyllabification. It can not shift to the penult **pa** because obligatory branching has not yet applied. Thus DTEs are affected only by resyllabification and obligatory branching.

13. In (50d) the high tone of the previous DTE syllable shifts to the final syllable. Cf. Sheldon (1974) for one analysis of this phenomenon. High tone in effect "follows" the stress in certain morphemic combinations. I have no analysis of this high tone shift here. Only "perturbable" adjectives and verbs undergo this. In Hammonds (1984) theory of DTEs, only one is allowed per foot. Obligatory branching will require that the DTE appear on the heaviest syllable. Any other DTE which appeared with the foot prior to reconstruction will be redefined by obligatory branching as a nonDTE, weak node. Again, in the event that two (or three) potential DTEs are of equal weight, the default value will select the rightmost.

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